Chapter 2

The Chrysalis: Where Breakthroughs Come From

The year was 1965. The place was Clearwater, Florida. In his motel room[1], Keith Richards woke up in the hot, humid morning to find his guitar and a tape recorder on the bed beside him. Groggy and hungover, Richards rewound the tape and pressed 'play.' The hour-long tape contained 59 minutes of his own snoring. But the first thirty seconds held the opening bars and first lyric of what became the Rolling Stones' most iconic hit, the song 'Satisfaction.'[1] He didn't remember even touching the tape recorder.

Believe it or not, Richards' breakthrough moment follows the very same pattern as Einstein's discovery of the special theory of relativity, and it's the pattern we heard again and again when interviewing some of the world's greatest innovators while performing the research for this book. And it's the same pattern you've experienced if you've ever had a sudden epiphany in the shower.

Before you have a "shower moments," chances are something was on your mind. Perhaps a problem at work or an issue in a relationship. You'd probably been obsessing over the problem, trying to work it out in different ways. Then you stepped into the shower. Your mind wandered off as the water beat gently against you. You were no longer focused. Suddenly, seemingly out of the blue, the answer came to you.

What do your shower moments have in common with Keith Richards' and Albert Einstein's discoveries? When you got into the shower, you unknowingly switched brain modes. You had previously been deliberately focusing on the problem. But in the shower,

---

[1] The Rolling Stones weren't famous enough yet to afford hotels

your mind was probably wandering, idly daydreaming or seemingly “thinking about nothing.“ Neuroscientists have recently discovered that the secret to breakthroughs lies in our ability to switch between these two modes, the focused and the meandering.[2]

The focused mode is one you are already familiar with, because it’s the one you have been consciously using all your life. You can think of this mode as the ‘Executive mode:’ it’s the mode you use to execute, to get things done. Goal-oriented and deadline focused, it’s a champion at making lists, following timelines, and coming in under budget. The part of your brain responsible for this mode is called the Executive Network, or EN.[3]

The EN is a group of brain regions grouped near the front of your skull that help you focus on a task and accomplish a specific goal. You’re very well versed in using your EN. You did, after all, spend at least a decade in school specifically training those brain regions. As a matter of fact, you’re using your EN right now to read this sentence.

The EN allowed ancient people to track the patterns of the stars and the moon, figure out the best time to plant their crops, and organize the immense task of building at the pyramids. It’s also the function responsible for ‘social inhibition,‘ the form of self-control we use to function in society. Without your EN you are a three-year-old. With your EN you are a (hopefully) functional, responsible and productive member of society.

But your EN alone can’t create breakthroughs. It needs help from the more meandering network, the one that creates ‘shower moments.‘ This is the creative network we’ve mentioned earlier, the Default Network, or DN. You can think of the DN as a network or council of breakthrough geniuses inside your brain. The geniuses talk, exchange ideas, theories, sketches, half-baked theories and suppositions.

The DN is the source of all our creativity, all our invention, all our genius—and it hasn't gotten nearly enough recognition. What has the DN accomplished throughout history? A better question would be what great discoveries the DN hasn't played a role in. If the EN gives us the ability to focus and accomplish a task, the DN gives us the ability to look through the complexity of the world to see the patterns underneath.[4]

The DN is a vital component of your brain: research has made clear that this part of your brain is as essential to survival as your heart or your kidneys5. It's so important, in fact, that we could have written this entire book all about the DN. We would've said "Here it is! Here's how it works, here's how you can access it, here's how you can turbocharge it." But in fact, that's not enough. The DN, alone, can't create breakthroughs.

It's the ability to use both modes, to switch from one mode to another, that enabled Keith Richards to come up with 'Satisfaction' and Albert Einstein to discover the special theory of relativity. In fact, it's what enabled most discoveries in human history.]

So yes, we will cover how the DN works, how you can access it, and how you can turbocharge it. But we will then take you to the next level: how to get both networks to work together, or in other words how to learn to switch from one mode to the other and back again. This 'mode-switching' is what it's all about.

Here's how mode-switching works. As your brain takes in information via your five senses, some of it is used in immediate circumstances, such as: step over that rock, hit the brakes, someone just walked into the room—stop singing.

We also use information to build patterns. Some of the patterns are simple, such as: I like pizza from Marcello's. I don't like it when my mother calls because she gives

me guilt for not calling. This is the stuff of survival. (Especially with a Jewish mother. Trust us.)

Other patterns are more complex, such as: What is the series of notes, chords and bars that will become a song that will electrify American rock and roll? Try as it might, this was not a pattern that Richards' Executive mode could figure out.

In 1965, on their first American tour, The Rolling Stones were a mid-level group touring the country with their fourth album. They were seriously in need of a breakthrough hit, the kind of 'number one' song that would make them a household name. Richards' EN knew this and had been focusing on it. His Executive set a direction and defined a need, but it couldn't go so far as to come up with a solution.

When Richards fell asleep, his EN Executive was able to take a break from its usual work of thinking and executing. Imagine it taking a walk from its front office in the brain to the deeper, central part of the brain. There's a secret lounge there, where his council of breakthrough geniuses reside. We all have a lounge like that inside our brain.

While Richards' Executive was working in the brain's front office, the lights in the genius lounge were dim, because when the EN Executive is focused on accomplishing a specific task it draws much of your brain's power. But with the front office on break, the power is now re-routed to the secret genius lounge, and when Richards' Executive opens the door, things are buzzing.

Imagine a lounge full of plush couches, bean bags, drinks and snacks, white boards and sticky notes and different colored pens and colored dots. Leonardo da Vinci is sitting in a corner doodling on his sketch pad. Napoleon is playing with toy soldiers. Euclid is dancing with glow sticks Marie Curie gave him. Michelangelo is wrapping

play-doh around a pencil. Theresa de Avila is writing in her diary. Erasmus keeps bothering her by asking her if she's worried about the fate of mankind. Steve Jobs is telling Einstein he's not thinking big enough. Sun Tzu is telling a story of his past victory to no one in particular. Joan of Arc is ruminating over her betrayal by the French. Sherlock Holmes is analyzing the environment for clues to his latest theory, and Amelia Earhart is taking a nap.

When it walks into the room, Richards' Executive asks for their attention. "Listen folks, we need a hit. See what you can come up with." A direction was set, a need was defined. Then—and this is important— the Executive heads out to do something else. It knows that it has to let the geniuses do their thing. Maybe it takes a walk, or knits a sock, or takes a shower. It can't be something too demanding, or it would draw the brainpower away from the lounge.

Meanwhile, back in the lounge, the lights start to glow hot and bright and the geniuses crank up the espresso machine. The geniuses are talking, writing, drawing, building Lego models of their theories or putting sticky notes up and moving them around. Michelangelo and Leonardo are sketching, Sun Tzu and Napoleon are strategizing, Theresa de Avila and Erasmus are reflecting, Joan of Arc is worrying. (We're not kidding, this is really what different parts of your DN do.) The ideas are flying. One theory leads to another, which leads to another.

The Executive regularly checks back in so that the geniuses can show it what they came up with. The Executive might make some comments and suggestions or clarify the direction, and then goes back to its crossword puzzle or daydream. Until one moment, during a walk, or in the shower, or in Richards' case in the middle of the night, the

geniuses get incredibly excited, and the Executive sees something spark. Something has come together.

That night in Clearwater, Keith Richards' genius council showed his Executive the first 8 bars of a song with a single lyric. The geniuses and the Executive looked at it together, then looked at each other and said *yes!* The Executive woke Richards up, made sure he recorded it, and then went off-task again so Richards could go back to sleep.

And that, in a nutshell, is the neuroscience of breakthroughs.

The neuroscience of *Satisfaction:*

The Executive sets the direction: write a hit song!

Richards falls asleep, his Executive leaves the front office

Power re-routes to the Genius Lounge; the brain has switched modes.6

The Geniuses come up with a song that the Executive recognized as a possible hit

The Executive rouses Richards from sleep and makes sure he recorded the song

Task completed, Richards fell back asleep as his Executive leaves the front office.

The Executive, amongst many other things, sets the direction for your genius council to follow. And once the genius council has come up with something, the Executive is the one that executes, that puts into practice the ideas the genius council comes up with. It's as if the Executive were giving the genius council a bunch of Legos and saying "see what you can turn these into." The Legos snap together the same way neurons do. Your genius council is constantly trying out new neural connections, and in this process, sometimes it discovers something novel and useful. Sometimes your genius

council makes a multicolored Lego mess. Sometimes, it puts together a locomotive, a spaceship, or the special theory of relativity.

If the DN is so important, why haven't you heard of it before?

Since 1929, neuroscientists have known the brain is in a constant state of activity, and that background noise surrounds our more rational processes, but only recently has that background noise been examined as anything more than a nuisance.[7]

Our modern biases are geared towards the logical, the structured, the efficient—all the things that the DN is not. As the DN's discoverer told us, "up until recently, our focus has been on making the brain do specific things, ignoring the background, default, non-conscious, non-directed activity." The default network is one of the most powerful tools at our disposal, but it is not task-focused.

And indeed, focus is a positive attribute. A bias for the Executive is a bias for what is feasible. But the top performers, the stars, the innovators, the geniuses, focus on both. Breakthroughs happen by mode-switching back and forth between the EN and the DN.

Dr. Marcus Raichle, who discovered the existence of the DN in 1997, named it thus because it's the mode that the brain defaults to anytime it isn't on-task. And this mode never actually shuts off, but rather quiets down when we are focused on something. The moment we switch off the task, we default to this network. Look out the window, bang! Default to the network. Get up to make coffee, bang! We default to the network.

Dr. Raichle told us that this unconscious processing "is truly most of what we really do; because if we didn't we'd be pretty hopeless." In fact, the network is always

on, always engaged, interrupted only when we have to perform a specific task. It uses twenty times more energy than the conscious, task-focused part of the brain. [8]

"The brain is active all of the time," Dr. Raichle told us, "whether you are awake or asleep, whether you're engaging in a particular task or you are daydreaming. The brain is operating almost at full capacity or full strength pretty much all of the time."

Unfortunately we are so busy--we have so many tasks to complete to do our jobs, hit our numbers, achieve our goals--that we leave less and less time for our genius council to work its magic. We live in an Executive's world, which makes it all the more difficult for us to sit still and let power reroute to the genius lounge. But the genius council's participation is essential to breakthrough thinking.

In the mid-1800's chemists were trying to discover the structure of the molecule Benzene, a key component in gasoline. German chemist Friedrich August Kekulé set his Executive to the task. But it was one night having switched off from his Executive mode that his genius council drew him a picture of a snake eating its own tail. [9]

Kekulé's genius council had given him the metaphor; his Executive interpreted the metaphor and solved the riddle: Benzene was a ring. With that, Kekulé ushered in the modern age of structural organic chemistry and the rise of the pharmaceutical industry Ever wonder why so many big pharmaceutical companies are German: Merck, Bayer, Roche, Schering? Kekulé set up his breakthrough lab at the University of Bonn.

Twenty-five years after the Kekule's breakthrough he was honored at a dinner. In his speech he first revealed how the breakthrough came to him. He was nodding off in front of a fire in the winter of 1861 when he had a vision of a snake biting its own tail. This prompted him to imagine benzene structured as a ring.

There is much debate about this story. Some chemists believe it to be apocryphal. Others argue that Kekule's studies of architecture in his first year of school were what helped him. We would argue it was Kekule's experiences that helped inspire him.

Kekule had a talent for understanding objects in three dimensional space. He was talented at drawing and studied architecture for two semesters. He took classes in clay modeling, wood carving, wood turning and glass blowing, which he was particularly skilled at. When he attended a lecture on experimental chemistry he became fascinated by the mystery of how atoms connected to build themselves into complex molecules.

Kekule was a chemist who was skilled at creating, forming, and imagining three dimensional structures. His training in the art of forms informed his inquiry into the structure of the benzene molecule. And as we will see this aligns perfectly with the default mode network and your breakthrough council.

We also believe that Kekule did, in fact, have that dream. It is a classic example of something we refer to as metaphorical insight, see chapter 1. If Kekule stated that he had the dream, why is there doubt? Because there are two schools of thought in science. One is a rationalist approach, I know what I can prove, I know what I can disprove, everything else is metaphysics. On the other hand you have people who believe that creative scientific thinking can not be explained solely through linear logic. Arthur J. Rocke, a scholar of Kekule, said, "Creative moments often come through nonrational processes."

Cyril S. Smith, a metallurgist and historian of science at Massachusetts Institute of Technology once said that he believes "a fundamentally new scientific idea always starts with a feeling of certainty with one's whole body, not just with the mind—an esthetic sense, a sensual step. This first step is absolutely essential…Practically every new scientific theory comes about from what might be called daydreams, when a scientist is not in a logical but in a sensual mode." This is because "something really new doesn't fit, it must break away from established patterns and seek a different relationship between components. It is always something that is illogical when you first get it." He stresses that this is but the first step in the process. "You then must apply logic, mathematics, and rigorous thought to test and extend the ideas. Many nuclei are erased by this process: Nothing ever grows out of them."

To his point, Kekulé had his dream in 1861 but he did not publish a paper until 1865. After describing the snake dream at the dinner honoring him, he said, "Let us learn to dream, and perhaps then we will find the truth. But let us also beware not to publish our dreams until they have been examined by the wakened mind."

This combination of learning to dream, trusting our dreams to direct us, but then using our waking mind to explore the new direction is at the heart of this book.

Kekulé, like Einstein, Edison, Dali, Tesla, Watt, and countless other innovators, achieved his breakthrough thanks to the back-and-forth switch between his Executive

Mode and his Genius Mode. In fact, Dr. Raichle told us that it was after leaving a meeting and walking down the hall that he had the breakthrough leading to the Default Network's discovery.

So how can you access your genius mode?

Sleep on it (yes, really)

Story callout:

Adam Cheyer is the creator of Siri, Apple's artificial intelligence iPhone voice assistant. Building Siri was a herculean design and programming task: the sheer number of variables, ability to understand varying speech patterns, ability to search based on the random ways people would request information and return the answers in a useful way were each a massive challenge in their own right. Thankfully, Cheyer had a secret weapon: ready access to his Genius Mode.

Although designing and building Siri was a highly structured task, Cheyer knew better than to try and logically grind out every answer. Instead, he told us, "I sleep on the issues I'm wrestling with." Cheyer, like Dali and Edison, has discovered the incredible breakthrough power of the hypnagogic and hypnopompic states, the half-asleep periods just before falling asleep and just before waking. These are times when our genius council runs on hyper drive.

"I go to bed around eleven, noodling on a problem as I fall asleep," he explained. By noodling on the problem as he falls asleep Cheyer uses his EN to deliberately and consciously focus his genius council on a question. But it's not just about falling asleep. Cheyer's "noodling" is a key element. He falls asleep *focused* on the question. By directing his genius council before sleep Cheyer is able to take advantage of the

hypnagogic and hypnopompic states.

Cheyer discovered how to use sleep as a mode-switching tool. He relies on his genius council to make new associations and deliver breakthroughs while asleep. In the morning he goes to his desk and uses his EN to process the night's harvest of ideas.

Morning after morning while first designing Siri, he would wake up with new insights from his DN. He'd use his EN to integrate them into the prototype he was building. Eventually, he felt that he had something concrete enough to show the rest of the world.

The hypnagogic and hypnopompic states are so fruitful for creativity because our inhibiting frontal lobes—where our EN's front office is located—are quiet, and our DN is running strong. [10]

Salvador Dali recommended sitting in a straight-backed, bony chair with your arms hanging over the sides. In one hand, held between you thumb and forefinger, he said to hold a heavy, metal key dangling over an upside down plate. Let yourself drift off to sleep. As you drift to sleep your fingers will let go the key and the sound of it hitting the plate will wake you. Write down or sketch whatever is in your mind in that moment.[11]

Falling asleep: accessing your hypnagogic state

[Exercise callout:

How to enter the hypnagogic state:

- Clear the room of clutter and distractions
- Have pen and paper, or your phone on airplane mode and set to take notes or voice recorder
- Dim the lights (or wear an eye mask)

- Ensure you're in a quiet place, or that only white noise is audible
- Don't get too comfortable—no wearing pajamas or getting in bed
- Try to find time at midday, or right after you've eaten, when you're just the right amount of tired
- Set your alarm for 10 to 15 minutes
- Take a moment to focus your brain on the problem, and then let it go. Relax and drift off.]

You'll have better luck with the hypnagogic state if you do some prep work. Sifting through memories of your problem, and partial solutions, or the contours of your question, and the relevant information you have before you go to sleep is important. It's up to you to set a direction for your brain to wander in. It is as if there were a reception desk in your brain saying "Welcome to hypnagogic state. What would you like your geniuses to ponder?" You answer the question by thinking about the problem.

Have a pad and pencil or a phone voice recorder nearby, but no other distractions. Nothing to get in the way of you recording whatever information came from the hypnagogic state, whether it comes in the form of words or an image.

Dim lighting can help, too. When you're having an insight, your visual cortex goes into alpha waves—that is, your brain actually ceases to process visual information. In order to support the breakthrough ability of the hypnagogic state, you want to enable your visual cortex to go offline unimpeded. Low lighting is just the thing.

We recommend blocking the light rather than turning it off entirely simply because you might need the light to write, and you want to do as few things as possible between waking up and recording your ideas. You might try wearing an eye mask; this will block the light but will be fast and easy to remove, allowing you to begin recording your breakthrough almost immediately.

Sound can be a matter of personal preference. Some people will want to eliminate all sound; others may prefer white noise, a fan, nature sounds, or the television on low volume.

Research strongly indicates[12] that a mid-day nap enhances most people's cognitive abilities for the rest of the day, and that we get the most benefits from naps that last 15-25 minutes. So if you try this exercise and don't awaken with a breakthrough, you'll at least be sharper and more productive for the rest of the day.

If you want to go high-tech, consider Napwell, a project by MIT and Harvard Medical School students that uses sleep cycle monitoring to optimize napping. Waking up during the deep sleep portion of your cycle makes you groggy and unproductive, but Napwell monitors your sleep cycle to wake you up at the optimal time, and even uses light to mimic a natural sunrise.

Don't get frustrated if you find you're not actually falling asleep: first, it might take some practice and second, breakthroughs often come while relaxed and mind-wandering but not asleep.

Waking up: accessing the hypnopompic state

Deep sleep is not only allowed but required to access the hypnopompic state, so fluff those pillows and climb under the blanket. This is the state between rising out of sleep and coming into consciousness.

Presumably, hours will have passed since you fell asleep the night before, so it's imperative that you sent your brain in the right direction.

[Exercise callout:

How to access the hypnopompic state:

- Watch a documentary on something you know nothing about. Thinking about new narratives will trip new neural circuits and help your brain form new associations.
- Look through old photos. Your DN might find something valuable in a memory file you'd forgotten years ago.
- Read a book from your adolescence. Old thoughts and feelings will come rushing in.
- Take a walk outside. You'll simultaneously oxygenate your brain, flip the script on your bedtime routine, and see and feel things more interesting than your bathroom.
- Choose a progressive alarm that starts out quietly and builds in volume. You don't want to be jolted awake, bypassing the liminal state you were trying to take advantage of. Nature sounds work well here.
- Have a recording device nearby, whether to write, type, or record your voice. The breakthroughs emerging from the hypnopompic state can be

fleeting and ephemeral, so if we don't record them, they'll retreat from us as we wake up.]

It's hard to ignore the number of creative geniuses who credit their successes to the hypnopompic state. "Half the time I get answers in the middle of the night," said Jeff Hawkins, who started the entire smartphone revolution when he created the Palm Treo and is now working on Grok, an artificial intelligence system based on how our brains neurons actually work. "I think about it while falling asleep and in the middle of the night I'll wake up and I'll lie in bed silently, in the dark and just think. It's very important that it is dark. And then the answer will just come to me."

Sleep is a great tool for accessing your Genius Mode; and Judah has often woken up with great new ideas. He will often finish a conversation with a client by saying "alright, I'll have an answer in the morning." His clients then wake up to an answer in their inbox. Olivia, on the other hand, has never woken up with a new insight. When she naps, she wakes up groggy, hungry, and slightly grumpy. If she fell asleep with marbles in her hand, she'd probably wake up when they bounced off the ground thinking "What idiot is making such a bloody noise?" So don't beat yourself up if the hypnagogic and hypnopompic states don't do much for you.

---

[1] Anderson, Stacey "When Keith Richards Wrote '(I Can't Get No) Satisfaction' In His Sleep" Rolling Stone. May 9, 2011.

[2] Discussions and interviews with Dr. Kalina Christoff, head of the Cognitive Neuroscience of Thought Laboratory at the University of British Columbia.

Beaty, Roger E., Mathias Benedek, Scott Barry Kaufman, and Paul J. Silvia. "Default and executive network coupling supports creative idea production." *Scientific reports* 5 (2015).

Fox, Kieran CR, R. Nathan Spreng, Melissa Ellamil, Jessica R. Andrews-Hanna, and Kalina Christoff. "The wandering brain: Meta-analysis of functional neuroimaging studies of mind-wandering and related spontaneous thought processes." *Neuroimage* 111 (2015): 611-621.

Ellamil, Melissa, Charles Dobson, Mark Beeman, and Kalina Christoff. "Evaluative and generative modes of thought during the creative process." *Neuroimage* 59, no. 2 (2012): 1783-1794.

[3] Bressler, Steven L., Menon, Vinod “Large-Scale Brain Networks in Cognition: emerging methods and principles.” Trends in Cognitive Sciences 14 (2010) 277-290

[4] Buckner, Randy L., Jessica R. Andrews-Hanna, and Daniel L. Schacter. "The brain's default network." *Annals of the New York Academy of Sciences* 1124, no. 1 (2008): 1-38.

Also discussions with Dr. Marcus Raichle, Dr. Jonathan Schooler Dr. John Kounius and Dr. Kalina Christoff

[5] Conversations with Dr. Marcus Raichle. “I’ve never seen anyone suffer damage to that part of the brain from a stroke and survive.” Every mammal down to the mouse has been found to have a default network. It has two blood supplies, a form of redundancy found in vital parts like the heart and the liver.

[7]Berger, H., 1929. Über das Elektrenkephalogramm des Menschen. Archiv Für Psychiatrie Und Nervenkrankheiten 87, 527-570. Berger demonstrated that the human brain remains electrically active even at rest while attention wanders

[8] The Salience Network is a network of regions that, among other things, focus our attention on the most salient information at any time. This network has been found to actually direct our attention either to people, facts, or events outside of us, external, or to things happening inside of us. It mediates between our EN and our DN. It consists of the anterior insula (AI) and dorsal anterior cingulate cortex (dACC), the amygdala, the ventral striatum, and the substantia nigra/ventral tegmental area. Things that catch the salient networks eye include anything out of the ordinary, that breaks a pattern, anything surprising, pleasurable, rewarding, relevant to the self or engaging the emotions.

Menon, Vinod, and Lucina Q. Uddin. "Saliency, switching, attention and control: a network model of insula function." *Brain Structure and Function* 214, no. 5-6 (2010): 655-667.

[9] O. T. Benfey (1958). "August Kekulé and the Birth of the Structural Theory of Organic Chemistry in 1858". *Journal of Chemical Education*. **35**: 21–23. doi:10.1021/ed035p21.

[10] Fox, Kieran CR, Savannah Nijeboer, Elizaveta Solomonova, G. William Domhoff, and Kalina Christoff. "Dreaming as mind wandering: evidence from functional neuroimaging and first-person content reports." *Frontiers in human neuroscience* 7 (2013): 412.

[11] Dali, Salvador “50 Secrets of Magic Craftmanship.” Dover 1948

[12] Some people feel that naps leave them in a zombie-like state for the rest of the day. If that's your case, just use these tools in the evening at bedtime.